A Note on Supporting Method for Making Recipe Using Local Foods with Constraints

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Summary
In recent years, the Ministry of Agriculture, Forestry and Fisheries encourages local production for local consumption in Japan. But supporting method for making recipe using local foods has not been studied yet in previous research. So, this paper studies a supporting method for making recipe using local foods. We also consider constraints on a cost of ingredients and a rate of local production for local consumption.

Key words:
recipe, local production for local consumption, ingredient thesaurus, constraint

1. Introduction

In recent years, the Ministry of Agriculture, Forestry and Fisheries encourages local production for local consumption in Japan[2]. It is encouraged to consume local foods in local production for local consumption. Many new recipes are thought up in order to contribute to local production for local consumption. But it is difficult to think up many new recipes by oneself.

There are many previous studies on cooking recipes in the field of computer sciences. In previous studies[3][5][6], searching methods which find appropriate existing recipes are proposed. In previous studies[1][4], supporting methods which explain how to cook existing recipes are proposed. But a supporting method for making new recipe using local foods is not studied yet. So this paper studies a supporting method for making new recipe using local foods.

Generally, the cost of ingredients used in a recipe is one of important measures. In order to contribute to local production for local consumption we want to use many local food materials as ingredients. We propose a rate of local production for local consumption in order to measure an amount of local food materials used in a recipe. We study a supporting method for making new recipe using local foods with constraints on the cost and the rate of local production for local consumption.

At first we propose a simple supporting method for making new recipe using local foods with constraints. But the simple proposed method doesn't work efficiently. So we also propose an improved method which works more efficiently.

We describe various information used in this paper in section 2. We propose a simple supporting method and an improved method in section 3. We explain some examples of application of proposed methods in section 4. Section 5 concludes the paper.

2. Information to be Used

Here, various information is defined for use in this paper. In the supporting methods for making recipes using local foods with constraints, three databases(DBs) are used: an ingredient DB, an existing recipe DB and an ingredient thesaurus.

Information about ingredients is stored in the ingredient DB. g_i , $g_i \in G$ denotes the i th ingredient in the ingredient DB. G , $G = \{g_1, g_2, \ldots, g_{|G|}\}$ denotes a set of ingredients in the ingredient DB. $c_1(g_i)$ denotes the cost(in Japanese yen) per 1 gram of ingredient g_i . $c_2(g_i)$ denotes the energy(kcal) per 1 gram of ingredient g_i .

Information related to existing recipes, which serves as the original information for making new recipes, is stored in the existing recipe DB. r_i , $r_i \in R$ denotes the i th existing recipe in the existing recipe DB. R , $R = \{r_1, r_2, \ldots, r_{|R|}\}$ denotes a set of existing recipes in the existing recipe DB. $f(r_i, j)$, $f(r_i, j) \in F(r_i) \subset G$ denotes the j th ingredient of the existing recipe r_i . $F(r_i)$, $F(r_i) = \{f(r_i,1), \ldots, f(r_i, |F(r_i)|)\}$ is a set of ingredients of the existing recipe r_i . $w(r_i, j)$ denotes an amount(gram) used for one person of the j th ingredient of the existing recipe r_i .

When cooking, one sometimes doesn't use ingredients specified in the recipe but substitutes other ingredients for them. That practice requires the knowledge of the cook who substitutes ingredients to provide delicious foods. We use the knowledge of the cook as an ingredient thesaurus

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for such substitutable ingredients, especially on local foods.

In the field of natural language processing, synonym dictionaries for computers are provided as thesauri. For information retrieval in natural language processing, the thesaurus is used for query expansion, by which new information that was unretrievable using only an original keyword can be retrieved by adding a logical sum of synonyms having the same meaning as the original keyword, but a different notation. The idea of substitute ingredients in this paper resembles the idea of synonyms in natural language processing. Therefore, it is called an ingredient thesaurus in this paper.

b_i , $b_i \in B \subset G$ denotes the i th ingredient to be substituted(original ingredient to be substituted) stored in the ingredient thesaurus. B , $B = \{b_1, b_2, \ldots, b_{|B|}\}$ denotes a set of ingredients to be substituted in the ingredient thesaurus. $a(b_i, j)$, $a(b_i, j) \in A(b_i) \subset G$ denotes the j th ingredient(local food material) to be substituted that is substitutable in that an ingredient b_i to be substituted is edible as delicious food, even by being substituted for the relevant ingredient. $A(b_i)$, $A(b_i) = \{a(b_i,1), a(b_i,2), \ldots, a(b_i, |A(b_i)|)\}$ is a set of substitute ingredients regarding the ingredient to be substituted b_i . $m(r_j, k)$, $m(r_j, k) \in M(r_j) \subset B$ denotes the k th ingredient used in r_i and stored in the ingredient thesaurus as b_i mentioned above.

d is a constraint on cost of ingredients. In other words, d is the maximum allowable cost. A rate of local production for local consumption of recipe r_i is described as follows:

$$rate(r_i) = \frac{\text{total energy of local food materials in } r_i}{\text{total energy of ingredients in } r_i} . \quad (1)$$

e is a constraint on the rate of local production for local consumption. In other words, e is the minimum rate that can be allowed.

3. Proposed Methods

3.1 Simple Proposed Method

In this subsection we propose a simple method which makes new recipes based on an existing recipe r_i . There are some definitions. Sum_1 is the total cost of ingredients which are not elements of $M(r_i)$ but elements of $F(r_i)$. Sum_2 is the total energy of ingredients which are not elements of $M(r_i)$ but elements of $F(r_i)$. $SSum_2$ is the total energy of local food materials which are not elements of $M(r_i)$ but elements of $F(r_i)$.

$$V_{1,1} = c_1(a(m(r_i,1), j_1))w(r_i, I(r_i, m(r_i,1))), \quad (2)$$

$$V_{2,1} = c_1(a(m(r_i,2), j_2))w(r_i, I(r_i, m(r_i,2))), \quad (3)$$

$$V_{|M(r_i)|,1} = c_1(a(m(r_i, |M(r_i)|), j_{|M(r_i)|}))w(r_i, I(r_i, m(r_i, |M(r_i)|))), \quad (4)$$

$$V_{1,2} = c_2(a(m(r_i,1), j_1))w(r_i, I(r_i, m(r_i,1))), \quad (5)$$

$$V_{2,2} = c_2(a(m(r_i,2), j_2))w(r_i, I(r_i, m(r_i,2))), \quad (6)$$

$$V_{|M(r_i)|,2} = c_2(a(m(r_i, |M(r_i)|), j_{|M(r_i)|}))w(r_i, I(r_i, m(r_i, |M(r_i)|))), \quad (7)$$

where $I(r_i, m(r_i, l))$ is the index number in $F(r_i)$ for $m(r_i, l)$.

The simple method is given as follows:

$sum_1 = Sum_1$; $sum_2 = Sum_2$; $ssum_2 = SSum_2$;
for ($j_1 = 1$; $j_1 \le |A(m(r_i,1))|$; $j_1{+}{+}$) {
  $sum_1 = sum_1 + V_{1,1}$; $sum_2 = sum_2 + V_{1,2}$;
  $ssum_2 = ssum_2 + V_{1,2}$;
  for ($j_2 = 1$; $j_2 \le |A(m(r_i,2))|$; $j_2{+}{+}$) {
    $sum_1 = sum_1 + V_{2,1}$; $sum_2 = sum_2 + V_{2,2}$;
    $ssum_2 = ssum_2 + V_{2,2}$;
    ⋮
    for ($j_{|M(r_i)|} = 1$; $j_{|M(r_i)|} \le |A(m(r_i, |M(r_i)|))|$; $j_{|M(r_i)|}{+}{+}$){
      $sum_1 = sum_1 + V_{|M(r_i)|,1}$; $sum_2 = sum_2 + V_{|M(r_i)|,2}$;
      $ssum_2 = ssum_2 + V_{|M(r_i)|,2}$;
      if ($sum_1 \le d$ && $\frac{ssum_2}{sum_2} \ge e$) {
      generation of recipe $r'_{i,j_1,j_2,\ldots,j_{|M(r_i)|}}$ }
      $sum_1 = sum_1 - V_{|M(r_i)|,1}$; $sum_2 = sum_2 - V_{|M(r_i)|,2}$;
      $ssum_2 = ssum_2 - V_{|M(r_i)|,2}$;}
    ⋮
    $sum_1 = sum_1 - V_{2,1}$; $sum_2 = sum_2 - V_{2,2}$;
    $ssum_2 = ssum_2 - V_{2,2}$;}
  $sum_1 = sum_1 - V_{1,1}$; $sum_2 = sum_2 - V_{1,2}$;
  $ssum_2 = ssum_2 - V_{1,2}$; }

In the algorithm presented above, regarding each element(ingredient to be substituted) $m(r_i, j)$ of the set $M(r_i)$ of the ingredient stored in the ingredient thesaurus as the ingredient to be substituted among ingredient of existing recipe r_i , all combinations are listed while each element is made up to be substituted for from $a(m(r_i, j),1)$ to $a(m(r_i, j), |A(m(r_i, j))|)$. The index number of the substitution ingredients to be substituted is expressed by

j_k , $1 \le k \le |M(r_i)|$, $1 \le j_k \le |A(m(r_i,k))|$. A new recipe is expressed by $r'_{i,j_1,j_2,\ldots,j_{|M(r_i)|}}$. A use amount of the substitute ingredient $a(m(r_i, j), k)$ for one person is assumed to be equal to that of ingredient to be substituted $m(r_i, j)$. The total number of candidates of new recipe which are finally checked on constraints is $|A(m(r_i,1))||A(m(r_i,2))|\cdots|A(m(r_i,|M(r_i)|))|$. The number $|A(m(r_i,1))||A(m(r_i,2))|\cdots|A(m(r_i,|M(r_i)|))|$ is very big sometimes. Our simple proposed method doesn't work efficiently. So in the next subsection we propose an efficient method.

3.2 Efficient Proposed Method

In this subsection we propose an efficient method which makes new recipes based on an existing recipe r_i . There are some definitions.

$$W_{1,2} = \sum_{k=2}^{|M(r_i)|} Max(A(m(r_i,k)),2)w(r_i, I(r_i, m(r_i,k))), \quad (7)$$

$$X_{1,1} = \sum_{k=2}^{|M(r_i)|} Min(A(m(r_i,k)),1)w(r_i, I(r_i, m(r_i,k))), \quad (8)$$

$$W_{2,2} = \sum_{k=3}^{|M(r_i)|} Max(A(m(r_i,k)),2)w(r_i, I(r_i, m(r_i,k))), \quad (9)$$

$$X_{2,1} = \sum_{k=3}^{|M(r_i)|} Min(A(m(r_i,k)),1)w(r_i, I(r_i, m(r_i,k))), \quad (10)$$

where $Max(A(m(r_i,k)),2)$ is the maximum energy in $A(m(r_i,k))$. $Min(A(m(r_i,k)),1)$ is the minimum cost in $A(m(r_i,k))$.

The efficient method is given as follows:

$sum_1 = Sum_1$; $sum_2 = Sum_2$; $ssum_2 = SSum_2$;
for ($j_1 = 1$; $j_1 \le |A(m(r_i,1))|$; $j_1 ++$) {
$sum_1 = sum_1 + V_{1,1}$; $sum_2 = sum_2 + V_{1,2}$;
$ssum_2 = ssum_2 + V_{1,2}$;
if ($sum_1 + X_{1,1} \le d$ && $\dfrac{ssum_2 + W_{1,2}}{sum_2 + W_{1,2}} \ge e$) {
for ($j_2 = 1$; $j_2 \le |A(m(r_i,2))|$; $j_2 ++$) {
$sum_1 = sum_1 + V_{2,1}$; $sum_2 = sum_2 + V_{2,2}$;
$ssum_2 = ssum_2 + V_{2,2}$;
if ($sum_1 + X_{2,1} \le d$ && $\dfrac{ssum_2 + W_{2,2}}{sum_2 + W_{2,2}} \ge e$) {
… for ($j_{|M(r_i)|} = 1$; $j_{|M(r_i)|} \le |A(m(r_i,|M(r_i)|))|$; $j_{|M(r_i)|} ++$){
$sum_1 = sum_1 + V_{|M(r_i)|,1}$; $sum_2 = sum_2 + V_{|M(r_i)|,2}$;
$ssum_2 = ssum_2 + V_{|M(r_i)|,2}$;
if ($sum_1 \le d$ && $\dfrac{ssum_2}{sum_2} \ge e$) {
generation of recipe $r'_{i,j_1,j_2,\ldots,j_{|M(r_i)|}}$ }
$sum_1 = sum_1 - V_{|M(r_i)|,1}$; $sum_2 = sum_2 - V_{|M(r_i)|,2}$;
$ssum_2 = ssum_2 - V_{|M(r_i)|,2}$;} … }
$sum_1 = sum_1 - V_{2,1}$; $sum_2 = sum_2 - V_{2,2}$;
$ssum_2 = ssum_2 - V_{2,2}$;}}
$sum_1 = sum_1 - V_{1,1}$; $sum_2 = sum_2 - V_{1,2}$;
$ssum_2 = ssum_2 - V_{1,2}$; }

In the efficient proposed algorithm presented above, the total number of candidates of new recipe which are finally checked on constraints is smaller than that of the simple proposed algorithm.

4. Examples of application of proposed methods

Here, examples will be introduced in which the supporting methods for making recipes proposed in the previous section are applied to actual data. In the experiment whether the substituted ingredient in the ingredient thesaurus tastes good is determined by us, subjectively.

In the examples we use 3 existing Japanese recipes in Table.1.

Table.1 existing recipes

name of existing recipe	**ingredients in existing recipe**
[No.1] kakiage tempura	broad bean, shrimp, wheat flour, salt, pepper, cold water
[No.2] swordfish, eggplant and garlic curry	sword fish, eggplant, garlic, curry roux, salt, pepper, salad oil
[No.3] simmered chicken with long green onion	chicken leg, long green onion, ginger, soy sauce, sweet cooking sake, rice wine, water

Constraints on the cost of ingredients and the rate of local production for local consumption are set as follows:

$$d = 1000, \text{ (in Japanese yen)} \quad (11)$$

$$e = 0.7. \quad (12)$$

In the experiment a target area for local production for local consumption is Hokkaido in Japan. Local foods of Hokkaido are stored as $a(b_i, j)$ in the ingredient thesaurus. The results of experiment are shown in Table.2.

Table.2 results of experiment

existing recipe	number of final candidates		number of new recipes
	simple	efficient	
[No.1]	130	40	30
[No.2]	80	20	20
[No.3]	30	24	17

The number of new recipes in Table.2 represents the number of new recipes made by proposed methods. The efficient proposed method makes the same new recipes as the simple proposed method. The number of final candidates in Table.2 represents the number of candidates checked by the final check on constraints. The number of final candidates of the efficient proposed method is smaller than that of the simple proposed method. Therefore, it is obvious that the efficient proposed method works more efficiently than the simple proposed method.

5. Conclusion

Supporting method for making new recipe using local foods has not been studied yet in previous research. So, in this paper we study a supporting method for making new recipe using local foods. We also consider constraints on the cost of ingredients and the rate of local production for local consumption.

At first we proposed the simple supporting method for making new recipe using local foods with constraints. But the simple proposed method doesn’t work efficiently. So, we also proposed the efficient supporting method for making new recipe using local foods with constraints. We showed that the efficient proposed method works more efficiently than the simple proposed method by some experiments.

As further works we want to study a method which makes the ingredient thesaurus automatically based on existing recipes.

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